POWER SUPPLIES UNLIMITED

TR Line

NJE CORPORATION Kenilworth, New Jersey

INSTRUCTION MANUAL

TR LINE

HALF-RACK - BENCH TYPE

SERIES REGULATED

POWER SUPPLIES

SERIAL NUMBER _____

NJE CORPORATION
20 Boright Ave.
Kenilworth, N. J.
FSCM 98380

Telephone - 201-272-6000
Telefax - FFP
TWX: 201-276-7630

801584

WARNING

THIS EQUIPMENT EMPLOYS VOLTAGES WHICH ARE DANGEROUS AND CAN BE FATAL IF CONTACTED BY OPERATING PERSONNEL. EXTREME CAUTION MUST BE EXERCISED WHEN WORKING WITH THIS EQUIPMENT.

INTRODUCTION

DEVIATIONS

This manual covers the Standard NJE power supplies as indicated in Section 1 herein. Where deviations to the specifications are built into equipment at customer's request, the nature of the deviation as it affects this manual is indicated in a Specification Sheet which precedes Section 1. If special schematic drawings, parts placement drawings and spare parts lists are required for the deviation they will be found in Section V of the manual, in place of the Standard material.

CORRESPONDENCE

All correspondence must reference the complete description of the unit as shown on the identification label located at the rear of the unit.

In requesting spare parts or information relative to parts, the Reference Designation, the rating, the description and the NJE Part Number must be specified for each part in question.

DESIGN IMPROVEMENTS

N.J.E. Corporation reserves the right to make design improvements on any instrument without prior notice.

REPRODUCTION

No material, drawings, text, figures or any part of this instruction manual may be reproduced without express written consent of N.J.E. Corporation.

REPAIR SERVICE

N.J.E. Corporation provides complete repair facilities at the main plant and at local service centers as listed on the back of this manual. These repair facilities are adequately staffed with factory trained technicians to assure our customers of the most knowledgeable and expedient servicing of our equipment. All equipment forwarded to these facilities must be adequately packaged to prevent damage in transit.

OUT OF WARRANTY SERVICE:

Forward defective equipment to factory or local service center prepaid. A full description of difficulties encountered or the repair required should accompany this shipment. An estimate of the cost of repair will be submitted to you. The necessary servicing will be performed only upon receipt of your written service orders. Your equipment will be returned to you via collect shipment unless otherwise specified on your service order.

IN WARRANTY SERVICE:

If during the warranty period the power supply indicates an inherent defect, immediately communicate with your nearest NJE Field Representative in your area. If, after examination, he concurs that the unit is defective under the warranty conditions, he will provide written authorization for the return of the unit to the factory or the local field service center, whichever is nearest. N.J.E. Corporation will not assume any transportation charges on incoming equipment without the concurring written approval from its field representative.

TABLE OF CONTENTS

Section	Title		Page
I	Specifications		
	1.1	General	1-1
	1.2	Electrical Specifications	1-1
	1.3	Mechanical Specifications	1-3
	1.4	Optional Features	1-4
II	Installation and Operation		
	2.1	Unpacking	2-1
	2.2	Installation	2-1
	2.3	Standard Single Unit Installation	2-1
	2.4	Dualling	2-4
	2.5	Operation	2-5
III	Principles of Operation		
	3.1	General	3-1
	3.2	Detailed Circuit Description	3-1
IV	Maintenance		
	4.1	General	4-1
	4.2	Preventative Maintenance	4-2
	4.3	Measurements and Tests	4-3
	4.4	Troubleshooting	4-5
	4.5	Alignment and Adjustment	4-15
	4.6	Feedback Amplifier Check	4-16
	4.7	Stability Check	4-17
V	Drawings and Bill of Materials		

SECTION

SPECIFICATIONS

1.1 GENERAL:

The TR line of Half-Rack or Bench Type Series Regulated Power Supplies is designed for use in applications requiring a well regulated stable source of DC power. The specifications herein are tabulated where ratings change from unit to unit (See Table 1-1) and are generalized into paragraphs where ratings are common.

1.2 GENERAL ELECTRICAL SPECIFICATIONS:

1.2.1 Input: 105 to 125 Volts, 55 to 65 cps, single phase at approximately 1.8 amperes.

1.2.2 Output Voltage and Current: See Table 1-1.

1.2.3 Static Regulation:

1.2.3.1 Load: At constant input voltage, the regulation for load changes is less than 0.02% or 1 millivolt, whichever is greater, from half load to full load and less than 0.02% or 1 millivolt, whichever is greater, from half load to no load.

1.2.3.2 Line: At constant load, the regulation is less than 0.03% or 2 millivolts, whichever is greater, for a line change from 115V to 105V and less than 0.03% or 2 millivolts, whichever is greater, for a line change from 115V to 125V.

1.2.4 Ripple: 2 millivolts, peak to peak, maximum.

1.2.5 Transient Response: ±0.03% or ±2 millivolts, whichever is larger, for a ±10 Volt prolonged step change in line voltage. For a no load to full load or a full load to no load step change, the output voltage will return to within 10 millivolts of the regulated region in less than 50 microseconds.

1.2.6 Meters: Voltmeter and ammeter rated accurate to 2% of full scale value are provided on the front panel.

1.2.7 Polarity: The output may be "floated" up to 500V peak above ground. Either polarity may be grounded to chassis by means of terminals provided.

1.2.8 Duty: Continuous at ambient temperatures from 0° C to 35° C. Operation above 35° C is allowed provided the output current is reduced by 20% for every 10° C rise above 35° C.

1.2.9 Remote Sensing: Sensing terminals, separate from the output terminals, provide sensing and load regulation against the voltage at the load rather than the voltage at the power supply output terminals. This eliminates the otherwise unavoidable load regulation due to the voltage drop in the wires connecting the supply to the load. This feature does not eliminate voltage excursions resulting from load transients through load line impedance.

1.2.10 Remote Programming: The output voltage may be controlled accurately from a remote point if desired, by varying the resistance across the REMOTE PROGRAM terminals. The sensitivity of this circuit is approximately 140 ohms per volt above the minimum voltage within the voltage limits of Table 1-1.

1.2.11 Dualling: Two or more units may be operated in series to provide higher voltage output at rated current. Two like units may be operated in parallel provided that the total current drawn is derated by 10%. All dual unit installations must meet the cooling requirements of Paragraph 1.3.2. The effectiveness of 3 or more units in parallel can be determined only by a test of the system.

1.2.12 Termination: A barrier type terminal strip at the rear of the unit provides interface connection for input, output, remote sensing, remote programming and ground. Front panel binding posts for output termination and ground in addition to the output terminals at the rear are provided.

1.2.13 Protection: Load and power supply protection for any overload condition is accomplished by an electronic current limiting circuit. Protective fuse will interrupt input power in the event of internal failure.

1.2.14 Output Capacitor: The output capacitor is permanently connected to the output terminals.

1.2.15 Constant Current: Improved current regulation can be achieved by sensing across an appropriate external resistor in series with the load. No internal modifications are required.

1.2.16 Resolution: Continuously variable single turn Output Adjust potentiometer provides the resolution indicated in Table 1-1.

1.3 MECHANICAL SPECIFICATIONS:

1.3.1 Outline Drawing: Table 1-1 indicates which Outline Drawing is applicable to the unit in question.

1.3.2 Airflow: All units have internal blowers and depend on forced air cooling in addition to conduction and convection cooling. Air flow paths as indicated in the appropriate Outline Drawing must not be blocked.

1.3.3 Mounting: Unit is designed for bench mounting. Rack adapters are available as follows:

1.3.3.1 NJE Model RP1, adapter to mount one unit centered on a standard 19" rack panel 5-1/4" high: order NJE Part No. 080539.

1.3.3.2 NJE Model RP1A, adapter to mount one unit offset to the left on a standard 19" rack panel 5-1/4" high: order NJE Part No. 081855.

1.3.3.3 NJE Model RP2, adapter to mount any two units on a standard 19" rack panel 5-1/4" high: order NJE Part No. 080537.

1.3.4 Finish: Exterior finished in dark grey enamel equivalent to FED STD 595 chip #26132. Panel marking is white. All other finishes are appropriate paint, plating or chemical film as required.

1.4 OPTIONAL FEATURES:

The specific optional features which are available on any given unit and the general description of these optional features follows:

1.4.1 Suffix (-P): Addition of three wire power cord and plug.

1.4.2 Suffix (-SF): Non-standard finish exterior of unit.

1.4.2.1 Where specifying (-SF) option customer must provide NJE the following information:

Color to be used (preferably FED STD 595 chip number).

Color to be used for marking.

Process to be used if other than NJE Standard finish process.

Whether paint is to be supplied by customer or NJE.

1.4.3 Suffix (-LV): Output Adjust potentiometer and knob replaced by a single turn, screwdriver adjust potentiometer with shaftlock.

1.4.4 Prefix (E): Deletion of meters.

1.4.5 Suffix (-TT): Replacement of standard Output Adjust potentiometer by a ten-turn continuously variable potentiometer with a decade dial and lock, providing an improved resolution of 0.02%.

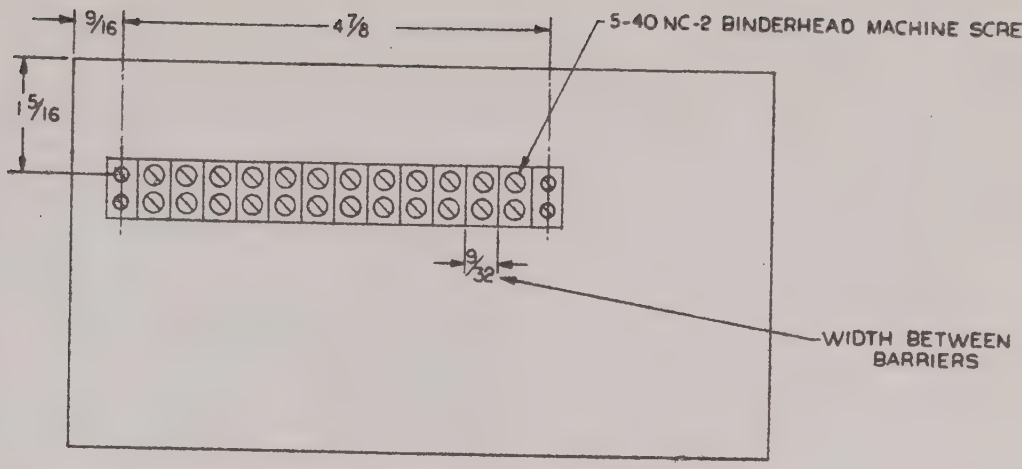
1.4.6 See paragraph 1.3.3 for rack adapters.

NOTE: Example of buildup of final model number for a TR-36-2 without meters and with line cord is as follows: ETR-36-2-P.

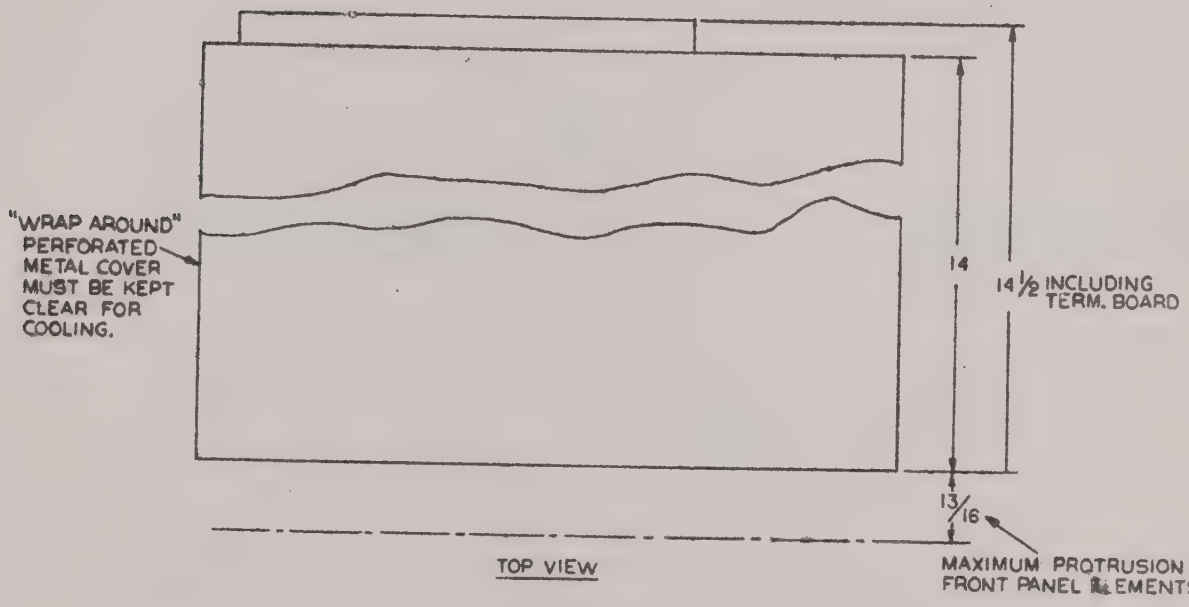
NOTE: NJE Corporation invites requests for quotations on special requirements which can be accomplished by deviations of standard catalogue units.

MODEL NO.	OUTPUT		WEIGHT		OUTLINE DWG	RESO-LUTION
	VOLTS	AMPS	NET	SHIP		
TR-18-3	0-18	0-3	18	28	303346 303351	50MV
TR-36-2	0-36	0-2	18	28	303346 303351	75MV

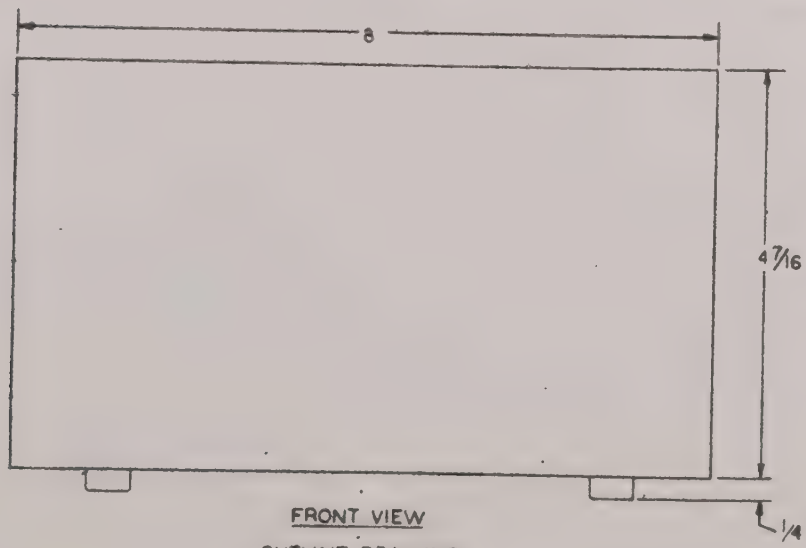
TABLE 1-1
TABULATED SPECIFICATION



REAR VIEW


"WRAP AROUND" PERFORATED METAL COVER MUST BE KEPT CLEAR FOR COOLING.
14
14 1/2 INCLUDING TERM. BOARD
13/16
MAXIMUM PROTRUSION OF FRONT PANEL ELEMENTS

TOP VIEW



FRONT VIEW

NOTE:
1 ALL TOLERANCES ± 1/32 UNLESS OTHERWISE SPECIFIED

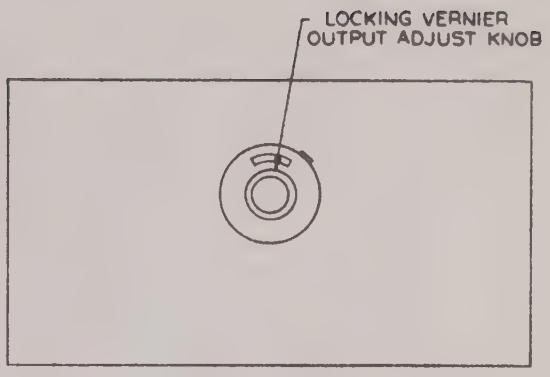
OUTLINE DRAWING
HALF RACK SUPPLIES

801614

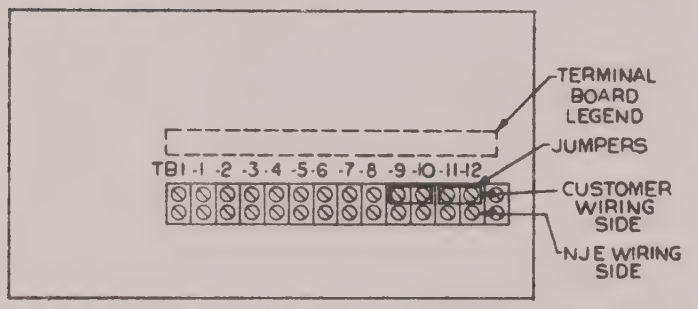
303346

TB1 TERMINAL BOARD LEGEND				
TERM NO.	SCREENED FUNCTION	RECOM'D WIRE SIZE	REMARKS	
1	AC	NO. 20 AWG	HIGH SIDE OF AC INPUT	
2	AC	NO. 20 AWG	RETURN SIDE OF AC INPUT	
3	GRD	NO. 20 AWG	AC GROUND	
4	NEG SEN	NO. 20 AWG	NORMALLY JUMPED TO NEG OUT	1
5	NEG OUT	NO. 20 AWG		
6	GRD	NO. 20 AWG	DC GROUND	
7	POS OUT	NO. 20 AWG		
8	POS SEN	NO. 20 AWG	NORMALLY JUMPED TO POS OUT	1
9	DUALLING	NO. 20 AWG	NORMALLY JUMPED TOGETHER	2
10				
11	REMOTE PROGRAM	NO. 20 AWG	NORMALLY JUMPED TOGETHER	1
12				

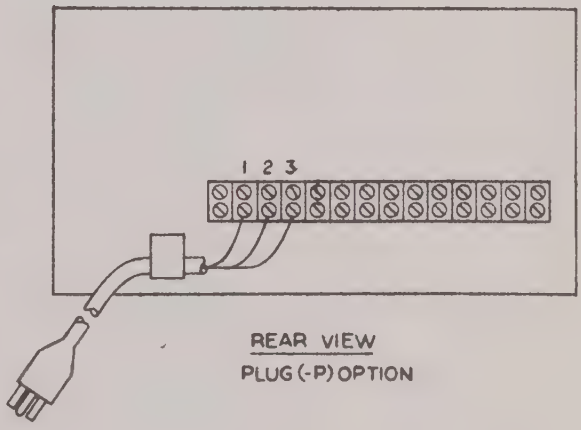
1. TWISTED PAIR WHERE USED
2. TERM. NO. 10 IS DUALLING DRIVE POINT.



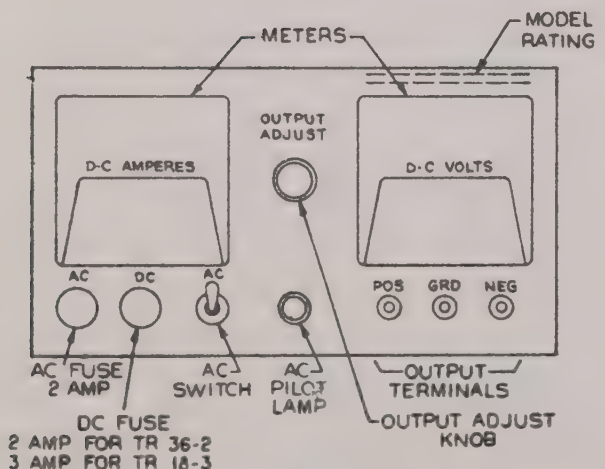
FRONT VIEW
OPTION (-TT)



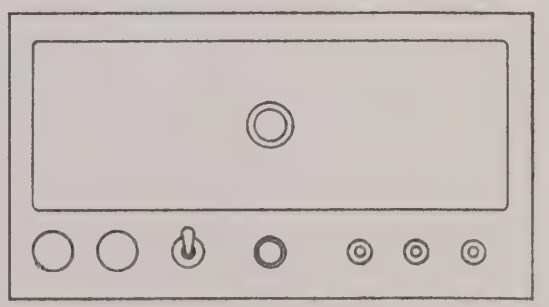
REAR VIEW
STANDARD UNIT



REAR VIEW
PLUG (-P) OPTION



FRONT VIEW
FRONT PANEL ELEMENTS, STANDARD



FRONT VIEW
NON METERED FRONT PANEL ELEMENTS
(E) OPTION

TR LINE

SECTION II

INSTALLATION AND OPERATION

2.1 UNPACKING. The power supply is shipped in a corrugated carton which is floated on sufficient insulation in a heavy-duty shipping carton. Aside from normal precaution against damage to the unit in opening the cartons and removing the unit, no special procedures are required. The carton should be opened immediately upon receipt and the contents inspected for shipping damage. The Power Supply was checked electrically and mechanically before it left the factory, and is warranted to be in perfect operating condition. This warranty does not cover possible damage incurred during shipment. Therefore, any evidence of mishandling, such as broken, deformed or missing parts, should be brought to the attention of the transportation company and a claim should be entered. Remove top cover plate and inspect all components and wiring, both on the chassis and panel, as well as the mechanical condition of the housing. The literature packed with the supply should be removed and held for reference in operating the equipment.

2.2 INSTALLATION: Refer to Table 1-1. which indicates which Outline Drawing is to be followed for the model in question. This Outline Drawing shows mounting dimensions, air flow requirements, interface wiring information and other data pertinent to proper installation. Careful observance of All the specification requirements in Section 1 is essential to a proper installation. READ THE SPECIFICATIONS CAREFULLY BEFORE PROCEEDING.

When the unit has been properly placed in position or mounted in its rack and secured in place by the panel screws, electrical connections should be made in accordance with the following step-by-step procedure. Wire sizes to be used and the terminal locations are specified on the appropriate Outline Drawing of Section 1-3. Terminal functions listed in the following instructions are clearly screened on the equipment itself, as well as being indicated on both the outline of Section 1-3 and the schematic drawing of Section 5.

2.3 STANDARD SINGLE UNIT ELECTRICAL INSTALLATION.

2.3.1 Output Grounding: Connect either the positive (POS OUT) or negative (NEG OUT) DC output terminal of the supply (depending upon desired output polarity) directly to the chassis ground terminal (GRD) at the barrier strip on the rear of the chassis, and connect the ground terminal to the system ground.

NOTE: If it is necessary that the power supply circuit float above or below ground, it is recommended that the output terminal should be connected to the chassis ground terminal by a 0.1 microfarad 600 VDC capacitor in place of the direct connection. Use of this by-pass capacitor will improve the stability of the circuit in the ungrounded condition, and reduce the effect of external interference and hum. Refer to Polarity Specification in Section 1 for maximum limitation on floating voltage permitted.

2.3.2 Output Connection: Connect the positive and negative output terminals (POS OUT) and (NEG OUT), respectively to the corresponding terminals of the external load. Use heavier gauge wire than that specified if long distances to the load are involved.

2.3.3 REMOTE SENSING: All units are shipped from the factory with the REMOTE SENSING feature jumpered out on the inter-connection terminal board as follows: (POS SENS) connected to (POS OUT) and (NEG SENS) connected to (NEG OUT). With this connection, the regulation specifications are met ONLY at the output terminals of the supply. If it is desired to have accurate regulation at the remote load point, rather than at the output terminals, proceed as follows:

Connect the output terminals to the load per Paragraph 2.3.2 above. Remove the Jumpers from (POS SENS) to (POS OUT) and (NEG SENS) to (NEG OUT) respectively. Observing correct polarity, run a twisted pair of No. 20 AWG wire (or larger) from (POS SENS) to the positive load point and from (NEG SENS) to the negative load point.

WARNING: DO NOT OPERATE POWER SUPPLY WITHOUT THE SENSING LEADS CONNECTED EITHER REMOTELY OR LOCALLY. MOST CUSTOMER COMPLAINTS OF POOR OPERATION ARE DUE TO IMPROPER SENSING LEAD CONNECTION.

WHEN THE POINT OF REMOTE SENSING IS MORE THAN 10 FEET FROM THE POWER SUPPLY, OSCILLATIONS MAY DEVELOP. A POSSIBLE CURE IS TO CONNECT REMOTE CAPACITANCE AS DESCRIBED IN PARAGRAPH 2.3.4 AND AS CLOSE TO THE POINT OF SENSING AS IS PHYSICALLY POSSIBLE.

2.3.4 Output Capacitor Connections: This feature is not provided on all units. When included in the equipment, the terminals are listed as (POS CAP) and (NEG CAP) on the Outline Drawing. The power supply has been shipped from the factory with the appropriate filter capacitors connected to the appropriate output terminals at the interconnection terminal board, This arrangement is satisfactory for most applications. However, if better transient and dynamic characteristics are required, further improvement can be effected by using an independent capacitor mounted as close to the ultimate load as is practical.

The capacitor used should have the same voltage rating of the power supply output capacitance (see the schematic drawing for the rating of the capacitor connected to the Pos Cap and Neg Cap terminals) and at least the same capacitance rating should be used. Additional capacitors may be ordered by specifying the NJE Part Number of the output capacitor from the Spare Parts List of Section 5.

Reconnections are made as follows: Remove the jumper connection provided between (Pos Out) and (Pos Cap) and between (Neg Out) and (Neg Cap). The load leads should be connected as in paragraph 2.3.2 above. Connect the new capacitor directly at the load being careful to observe polarity. In order to make this connection effective, it will be necessary to utilize the Remote Sensing Connections described in paragraph 2.3.3 above.

2.3.5 REMOTE PROGRAM: To utilize the Remote Programming feature of the unit, remove the jumper across the REMOTE PROGRAM terminals and connect a resistor across the REMOTE PROGRAM terminals. If the resistor is to be located remotely from the power supply, a pair of No. 20 AWG twisted wires should be used. The resistance (R) of the remote program resistor may be calculated as follows:

$$R = (\Omega/V) \quad (V_o - V \text{ min}) \text{ ohms}$$

Where (R) is the desired resistance, (Ω/V) is the Remote Programming sensitivity from Section 1. (V_o) is the desired output voltage and (V_{min}) is the minimum voltage allowed for the power supply as specified in Section 1.

When using this connection the OUTPUT ADJUST potentiometer should be set to zero (extreme counter clockwise position).

WARNING: DO NOT OPERATE THE POWER SUPPLY WITH THE "REMOTE PROGRAM" TERMINALS OPEN CIRCUITED.

2.3.6 INPUT CONNECTION:

2.3.6.1 Single Phase Units: Referring to the correct Outline Drawing as indicated by Table 1-1, connect the proper wire size specified to the two AC terminals, observing the "high" and "return" leads must be wired to the correct terminals. The system ground is connected to the GRD terminals associated with the AC input terminals.

2.3.6.2 Three Phase Units: All units which are specified in Table 1-1 as "208 volts, three phase", are intended to be used with a four wire system with the neutral connected. The outline Drawing indicated in Table 1-1 indicates the correct wire sizes to be used in wiring to the Phase A, Phase B, Phase C and Neutral terminals. In addition, the system ground must be connected to the GRD terminal associated with the AC input terminals. For those units where Table 1-1 specifies input of 460 volts three phase or 220 volts 3 phase 3 wire, the system is a three wire system with no neutral. The connection is similar to that of the four wire system except that no neutral lead is required.

2.3.7 CONSTANT CURRENT CONNECTION: Where specified in Section I, some NJE Power Supplies may be converted to Constant Current Regulated supplies. Figure 2-1 provides information for making this reconnection. Since there are numerous possibilities and parameters which must be considered, the information provided must of necessity be limited. For special applications, consult the factory Application Engineering Department.

On those units equipped with variable current limiting overload protection (See Section I), and where regulation requirements are restricted, Constant Current applications may be achieved directly without resorting to the more refined connection of Figure 2-1. This method of operation is described in Section 2-5.

2.4 Dualling:

2.4.1 COOLING OF DUAL UNIT INSTALLATION: Where the dual units are to be rack mounted one directly above the other, the filler panels referred to in Air Flow specification per paragraph 1.3.2 must be used. These panels may be ordered from NJE Corporation if the same finish is desired. For standard finish, 1-3/4 by 19" filler panels, order NJE Part Number 22164.

2.4.2 SERIES CONNECTION: Those NJE Power Supplies which may be connected in series, as indicated by the Dualling specification in Section I can be so connected using Figure 2-2A. IF "S" option is required, the unit should be ordered specifying the "S" option. Where field connection is required, reverse voltage protection diodes must be installed to protect against reverse voltage during a short circuit on the series connected supplies.

These diodes should have a Forward Average Current rating equal or greater than the output current rating of the supply and a Peak Inverse Voltage rating greater than the highest operating voltage of the application. The diodes must be connected in the nonconducting direction across the power supply output terminals. The series connection is quite straight forward and is essentially the same as connecting two batteries in series. Each supply is independently controlled and delivers an output voltage within its own capability. The total output voltage is, of course, the sum of that of the two supplies.

Connection of the series option, including the location of the reverse voltage protection diodes, is clearly shown in Figure 2-2A. The connection of the sensing leads is for the remote sensing mode of operation. If precise regulation at the load is not required, the sensing leads may be left jumpered at the respective output terminals as in paragraph 2.3.3.

2.4.3 PARALLEL CONNECTION: Those NJE Power Supplies which may be connected in parallel, as indicated by the Dualling Specification in Section 1, can be connected in parallel using Figure 2-2B. The total paralleled current must be derated by 10% from the individual current rating as the two supplies cannot be made to divide the load exactly.

2.5 OPERATION

2.5.1 The following check list should be followed before making the unit operational:

2.5.1.1 AC power switch in the OFF postion
2.5.1.2 VOLTAGE ADJUST potentiometer in the extreme counter clockwise position
2.5.1.3 CURRENT CONTROL potentiometer (where provided) in the extreme clockwise position
2.5.1.4 Input wiring made per paragraph 2.3.6
2.5.1.5 Output Grounding wired per paragraph 2.3.1
2.5.1.6 Output wiring made per paragraph 2.3.2
2.5.1.7 Remote Sensing wiring made per paragraph 2.3.3
2.5.1.8 Output Capacitor wiring (where provided) made per paragraph 2.3.4
2.5.1.9 Remote Programming wiring made per paragraph 2.3.5
2.5.1.10 Constant Current wiring (where provided) made per paragraph 2.3.7

2.5.1.11 Dualling connection (where desired) made per paragraph 2.4

2.5.2 Step by step operation based on the location of controls as indicated on the Outline Drawing specified in Table 1-1:

2.5.2.1 Energize the AC line

2.5.2.2 Operate the AC power switch to the On Position. The pilot lamp should lite.

2.5.2.3 While monitoring both output voltage and current, slowly rotate the VOLTAGE ADJUST potentiometer clockwise until the desired voltage level is reached.

2.5.2.3.1 If the desired voltage and/or current level (within the ratings of the unit) cannot be reached, de-energize the AC line and recheck all connections per paragraph 2.5.1 above. If still unable to achieve the desired levels, refer to the Trouble Shooting section at the rear of the Manual.

2.5.2.4 CURRENT CONTROL (where provided) may be set to the desired level as follows:

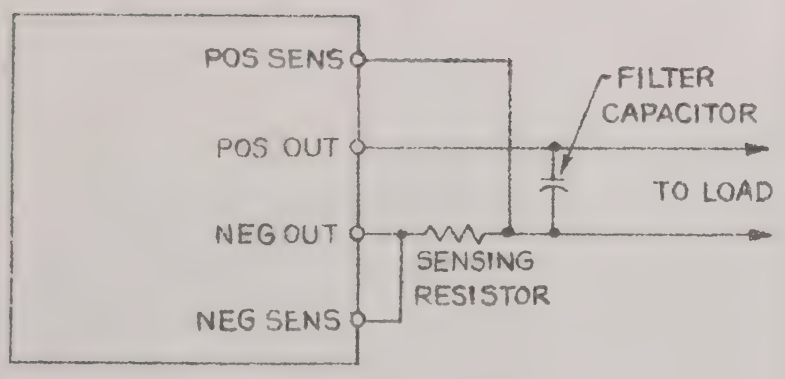
2.5.2.4.1 Method #1: While monitoring the load current, apply a short circuit across the load and rotate the CURRENT CONTROL potentiometer counter clockwise until the desired current level is reached.

2.5.2.4.2 Method #2: While monitoring the load voltage and current, adjust the load so that the desired levels are reached. Rotate the CURRENT CONTROL potentiometer slowly counter clockwise until the current level begins to fall off. A slight clockwise turn of the CURRENT CONTROL will then set the current limiting action just above the Operating level.

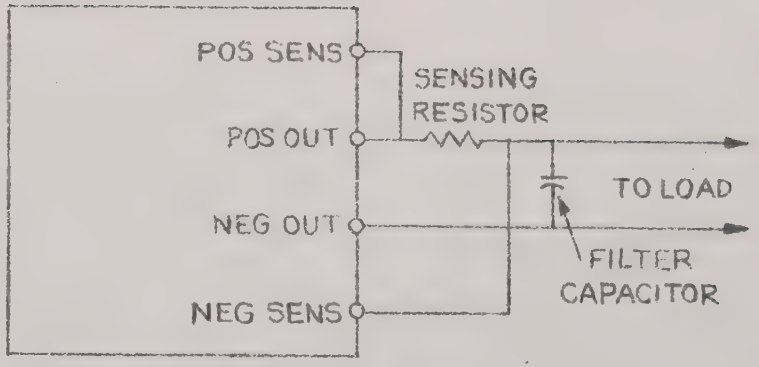
2.5.2.4.3 Method #3: Leaving the CURRENT CONTROL at the extreme clockwise position sets the current limiting action at approximately 110% of the maximum current rating of the supply.

NOTE 1: The current limiting feature is essentially a constant current device. As the load resistance is reduced toward an eventual short circuit condition, the load current will be limited to the preset CURRENT CONTROL setting, and it will hold at this value as the output voltage falls toward zero. The current regulation is better than 5% as the load resistance varies to cause a full swing of output voltage and is proportionally better for smaller load resistance changes.

NOTE 2: For the RVC and the RB Lines, which are provided with both voltage and current regulation with automatic crossover circuitry, the current limiting characteristic described above is highly regulated. Actual current regulation parameters are in accordance with the specifications noted in Section 1.



ALL UNITS EXCEPT TC LINE



TC LINE ONLY

PROCEDURE

1. SENSING RESISTOR SHOULD BE SELECTED TO PRODUCE APPROXIMATELY 1 VOLT DROP AT MAXIMUM DESIRED CONSTANT CURRENT. RESISTOR WATTAGE SHOULD BE AT LEAST FOUR TIMES MAXIMUM DISSIPATION FOR CURRENT STABILITY. SEE NOTE 4.
2. FILTER CAPACITOR SHOULD BE 6-10 MICROFARADS, OIL OR TANTALYTIC, WITH VOLTAGE RATING GREATER THAN MAXIMUM DESIRED OUTPUT VOLTAGE.

NOTE 1: SEE OUTLINE DRAWING, SECTION I, FOR TERMINAL CONNECTIONS AND WIRE SIZES.

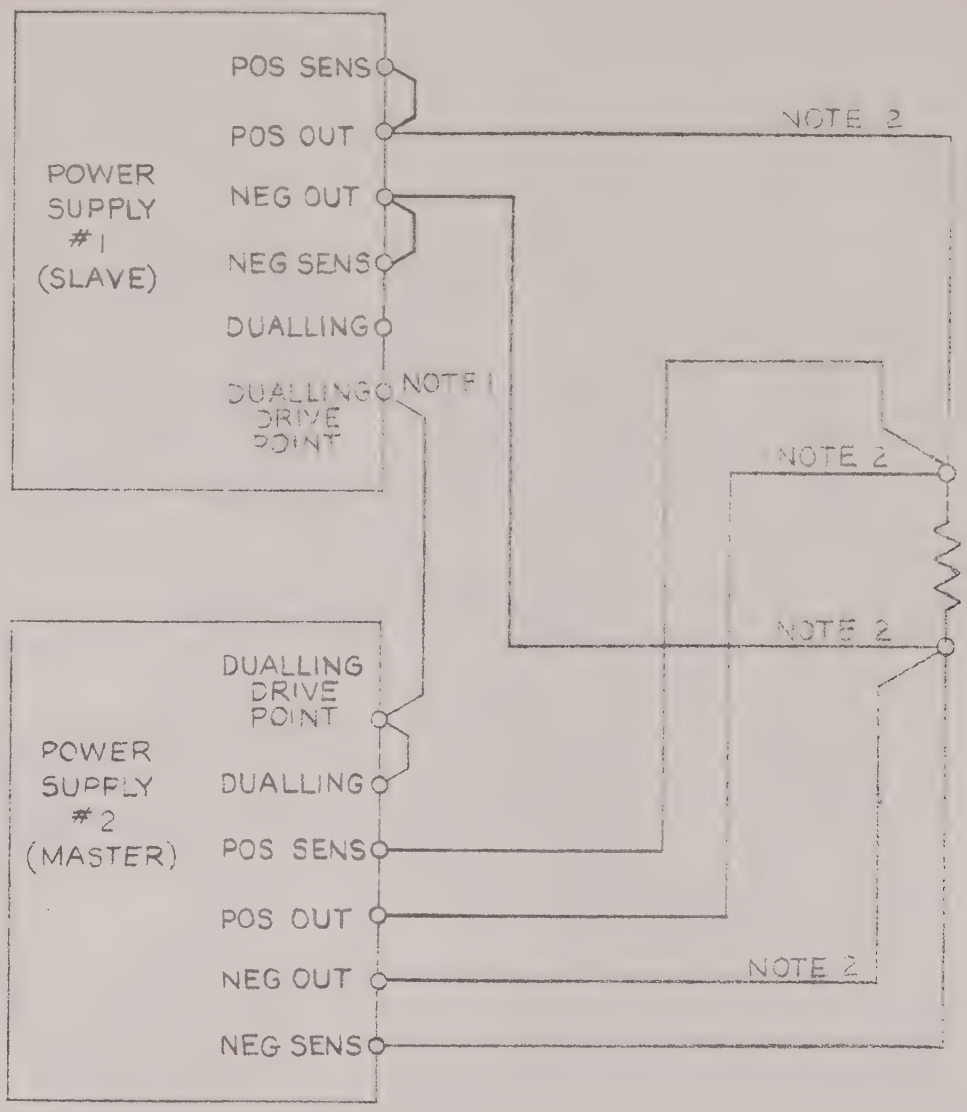
NOTE 2: ON TC UNITS, AN INTERNAL JUMPER BETWEEN TERMINALS 6 AND 11 ON PRINTED CIRCUIT BOARD A2 (96PC) MUST BE ADDED FOR CONSTANT CURRENT OPERATION.

NOTE 3: A POTENTIOMETER APPROXIMATELY 10% OF THE RESISTANCE OF THE OUTPUT ADJUST POTENTIOMETER SHOULD BE INSERTED IN THE PROGRAMMING TERMINALS. THE OUTPUT ADJUST SHOULD BE SET TO ITS MINIMUM POSITION. THE NEW POTENTIOMETER WILL THEN PROVIDE CURRENT CONTROL OVER THE DESIRED RANGE. IF DESIRED, THE OUTPUT ADJUST ITSELF MAY BE USED FOR CURRENT CONTROL, BUT ONLY THE LOWEST PORTION OF THE POTENTIOMETER IS USED. IF AVAILABLE ON THE SUPPLY, THE FINE CONTROL CAN PROVIDE ADEQUATE RESOLUTION.

NOTE 4: LOW TEMPERATURE COEFFICIENT RESISTORS WILL IMPROVE STABILITY.

CONSTANT CURRENT CONNECTION

FIG. 2-1

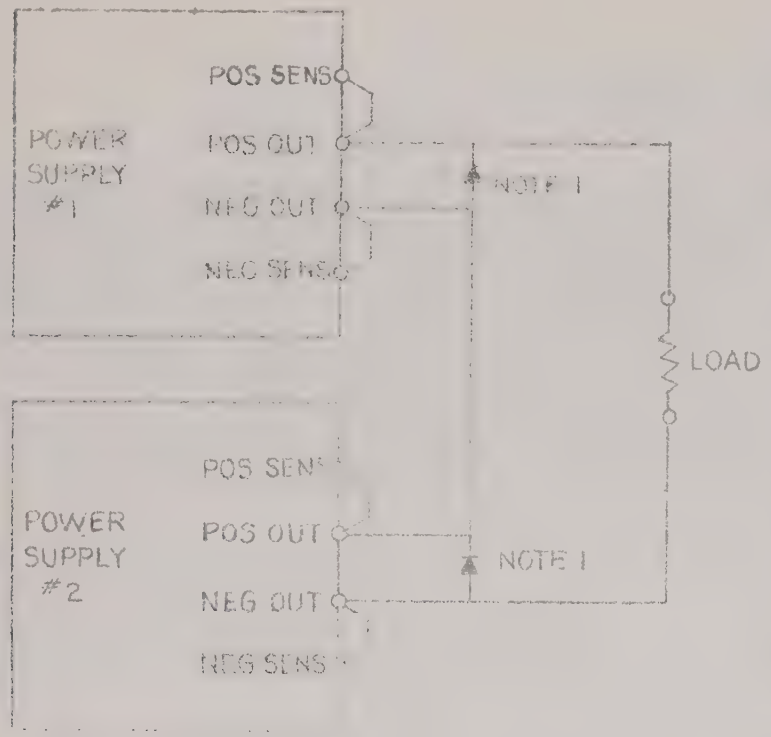


NOTE 1: JUMPER REMOVED FROM DUALLING TERMINALS ON "SLAVE" UNIT. INTERCONNECT DUALLING DRIVE POINTS BETWEEN "MASTER" AND "SLAVE" UNIT. SEE OUTLINE DRAWING, SECTION I, FOR TERMINAL CONNECTION AND WIRE SIZES, INCLUDING DRIVE POINT.

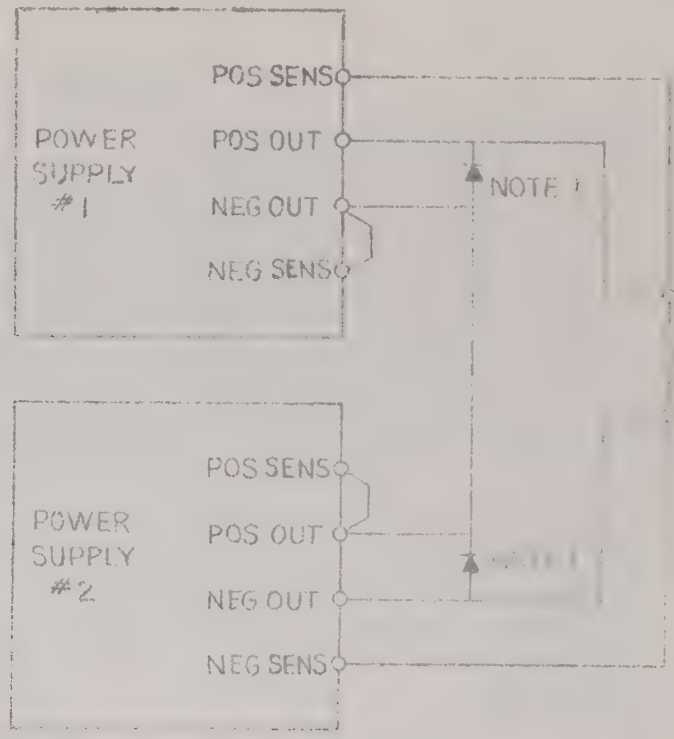
NOTE 2: LOAD LINE RESISTANCES SHOULD BE BALANCED CLOSELY FOR OPTIMUM OPERATION.

PARALLEL CONNECTION

FIG 2-2B



LOCAL SENSING



REMOTE SENSING

NOTE 1: REVERSE VOLTAGE DIODE, AS REQ'D. SEE PARA. 2.1.2.
SEE OUTLINE DRAWING, SECTION I, FOR TERMINAL CONNECTIONS AND WIRE SIZES.

SERIES CONNECTION

FIG. 2-2A

SECTION III

PRINCIPLES OF OPERATION

3.1 GENERAL:

A simplified block diagram, illustrating the basic elements of the circuit and the signal flow, is shown in Figure 3-1. The AC line voltage is converted to a practical value by the power transformer and rectified by a full-wave diode rectifier. A capacitor-input filter smooths the pulsating DC output of the rectifier, providing a low-ripple, unregulated DC voltage to the output regulator. The output voltage furnished to the load by the regulator is monitored by a feedback amplifier which compares this voltage with a stabilized reference voltage and amplifies the difference between the two voltages. The output of the amplifier is used to control the regulator in such a way that it counteracts any change in the DC output voltage, thereby furnishing an essentially constant voltage to the external load, despite variations in input line voltage or output load current.

3.2 DETAILED CIRCUIT DESCRIPTION:

Circuit references in the following material apply to the schematic diagram at the back of the manual. This diagram shows electrical relationships, without regard to actual physical location of the components, and is laid out in an arrangement approximately the same as that in the block diagram, Figure 3-1.

3.3 The power supply is energized by connecting 115 volts (nominal), 60 cycles, single-phase, to the input terminals, and closing switch (S1), attested by the lighting of pilot lamp (DS1).

3.4 The power transformer (T1) converts the primary line voltage to an appropriate value on its main secondary winding for operation of the power circuit. The transformer output voltage is rectified by diodes (CR1, CR2), providing a pulsating DC output which is smoothed by the capacitor-input filter (C3) and applied through a regulating transistor assembly (A2Q1, A2Q2 and A3Q1), to the external load. Capacitor (C9) provides additional filtering of the output, and reduces the internal impedance of the supply for high-frequency load variations.

3.5 The output voltage on the auxiliary secondary of transformer (T1) is rectified by diodes (CR3 - CR6), and filtered by capacitors (C4 - C5) to provide positive and negative operating potentials for the feedback amplifier. Zener diode (CR8) in conjunction with its load resistor (R9) provides a regulated + 5.6 volts DC, while diode (CR10) with resistor (R7) provides -18 volts DC (measured with respect to the neutral bus terminal 24 of the printed board). These zener diodes function in a manner analogous to that of a gaseous voltage regulator tube, providing a relatively constant output voltage across their terminals despite variations in the conducted current.

3.6 The feedback amplifier consists of two stages of balanced amplification, assuring minimum sensitivity to fluctuations in ambient temperature or operating voltages. The input signal for the amplifier is derived from a sensing voltage divider connected across the output of the supply. This divider consists of resistors (R24) and (R25) in the amplifier, and adjustable resistor (R16) on the front panel. The resistance value of (R16) and the remote programming resistor in series with it determines the operating value of the DC output voltage of the supply in a manner which will be explained below.

3.7 The negative end of the sensing voltage divider (negative end of resistor R24) is returned to the negative output of the supply through zener diode (CR13), the neutral bus terminal of the amplifier, and the negative sensing lead. The diode, in conjunction with its load resistor (R22), provides a highly stable potential of 5.6 volts DC for use as a comparison voltage by the input stage of (Q5 - Q6) of the feedback amplifier. When the output of the power supply (measured at the load) is precisely at its selected nominal value, the voltage at the base of transistor (Q6) (derived from the sensing voltage divider) is at the same level as the base of transistor (Q5), and the input stage is in balance. Under this condition, any tendency of the load voltage to vary in either direction will unbalance the amplifier, resulting in corrective action which compensates for the change, and holds the load voltage at its established value, as explained below.

3.8 Transistors (Q5) and (Q6) are NPN type units, operated in common-emitter mode, and connected as a balanced differential amplifier. Their outputs, taken across load resistors (R19) and (R20) are direct-coupled to the bases of the succeeding differential amplifier stage (Q3 - Q4), which consists of two PNP transistors operated in common-emitter mode. The output of (Q3), from its load resistor (R15), is tied directly to the base of the second driver transistor (Q2), which is emitter-follower coupled to the first driver transistor (Q1).

3.9 Regulation of the DC output is performed by transistor assembly (A2Q1, A2Q2, A3Q1) connected in series with the negative output. As directed by the output of the feedback amplifier, this transistor assembly adjusts its conductivity to continuously absorb the difference between the unregulated DC supply voltage and the selected DC output voltage, regardless of input line conditions or the load current drawn. Circuit protection is provided by resistor divider (R10, R11 and R12) in conjunction with diode (CR11). The divider is factory set to clamp the base of the second driver (Q2) when the load current increases above its rated value. The clamping action is achieved sharply by means of the decoupling diode which begins conduction when the base of (Q2) is driven sufficiently negative by load current flow through resistor (R8) and series regulator emitter resistors (R3, R4 and R5). This prevents any further current increase. (R11) is factory adjusted to limit the maximum current to a safe value and should not be disturbed. Since the regulating transistors exhibit some leakage at cutoff conditions, a bleeder resistor (R16) is used to provide a path for this current, so that the circuit will stay in regulation at zero load. Resistor (R6) serves the same purpose for the driver transistor (Q1).

3.10 The sequence of corrective action around the feedback loop is as follows: The input to transistor (Q5) is the zero reference level - in this case the voltage at the negative terminal of the load. The input to transistor (Q6) is given by the divider action of the resistor string (R16, R25 and R24) connected between the positive sensing point and the amplifier reference voltage at the negative end of (CR13). The divider feed point is the junction of (R16 and R25) and is tied to the input base through the small AC decoupling resistor (R23). The action of the high-gain negative feedback loop is such that the bases of input stage are brought into balance. In other words, the output voltage automatically obtains a value which will cause the voltage at the input base of (Q6) to balance that of (Q5). When the load voltage tends to deviate from the selected value in either direction, due to a change in load current or in input line voltage, this causes the voltage on the sensing divider to shift from its balanced level and the difference (or "error") voltage unbalances the amplifier stage (Q5 - Q6). This difference appears in amplified form in the output of this stage, and is further amplified by the subsequent amplifier stage before being applied to the driver transistors (Q2 and Q1). The output of the driver transistor causes the regulating transistor assembly (A2Q1, A2Q2, A2Q3) to increase or decrease its conductivity in accordance with the error signal so that its overall emitter-collector voltage drop absorbs the variation in load voltage, maintaining an essentially constant value of voltage across the load terminals.

3.10 (cont'd)

Capacitor (C10) assists the amplifier in responding to rapid changes in load voltage by bypassing a portion of the sensing circuit. The more rapid the change, the greater is the initial transfer of voltage direct to the input of the amplifier, enabling it to detect any radical load variation before the excursion becomes significant.

3.11 The sensitivity and speed of response of the corrective feedback circuit is such that the above-described action occurs almost instantaneously, and the actual excursion of the load voltage is held to a very small value. The circuit is a true proportional regulator, and must allow a small but finite "error" to exist between the required and actual regulated voltage, so that this error, however small, can generate the correction signal. By proper circuit design, the error is held to a value which remains within the specified regulation allowance of the power supply.

3.12 When resistors (R16) and/or the remote programming resistors are readjusted to produce a different value of output voltage, the circuit makes a correction similar to that described above. Altering the resistance in the sensing voltage divider unbalances the input stage of the feedback amplifier, which then causes the circuit to produce a new value of voltage such that the input bases return to their balanced condition. Reducing the value of the remote programming resistor, for example, momentarily increases the drop across (R24-R25) (assuming a constant value of the output voltage), causing the base voltage at (Q6) to rise above that of (Q5). However, this unbalanced condition at the amplifier input causes the DC output voltage to decrease until the drop across (R24 - R25) again equals the drop across (CR13) and the circuit stabilizes at this new operating point, establishing a lower value of DC output voltage.

3.13 Resistor (R24) in the amplifier is provided to permit compensation for manufacturing tolerances in diode (CR13), its load resistor (R22), and resistor (R25). (This resistor is adjusted at the factory and locked). If any of these components is replaced, check to see that full rated output voltage of the supply is obtainable with voltage control at maximum clockwise position. If not, readjust (R24) to provide full voltage under these conditions.

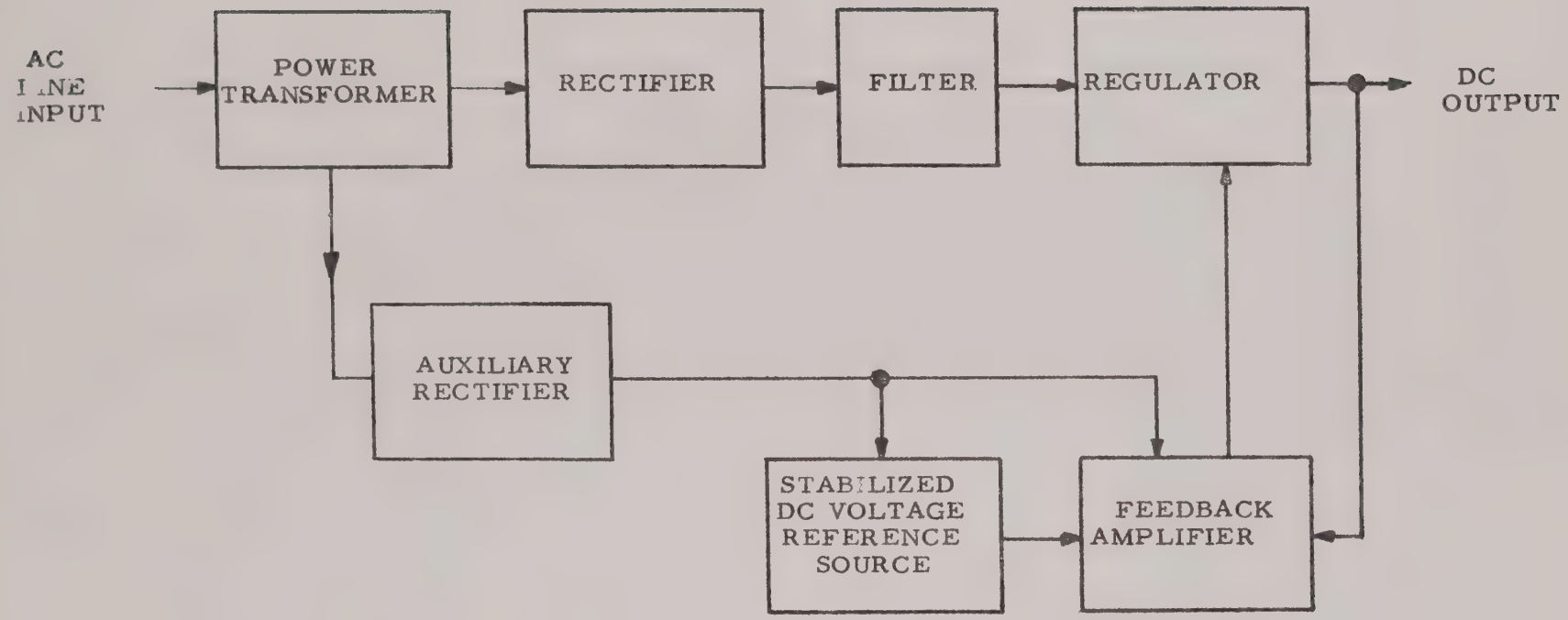


Figure 3-1

Simplified Block Diagram

SECTION IV

MAINTENANCE

4.1. GENERAL: Reference drawings for this power supply are provided in Section V. The exact Schematic Drawing is shown in Figure 5-1. Physical location of components is indicated in the Parts Placement Drawing in Figure 5-2.

This supply is designed for stable operation over long periods of time. However, if trouble develops, standard test equipment normally found in the Electronics Laboratory would be required. If the customer decides to do complete servicing on his premises, one or more of the following pieces of test instruments are required.

Instrument	Range	Remarks
DC Differential Voltmeter	0-500V	Precise regulation check
Oscilloscope	General Purpose	General troubleshooting
Vacuum Tube Voltmeter	General Purpose	Ripple measurements
Multimeter (Ohmmeter)		General troubleshooting
AC Voltmeter (Precision)	0-150V	Precise regulation check
Variable Autotransformer	0-140 V AC 8A	General troubleshooting
Dummy Load	Range depends on supply rating	

WARNING ! !

THE POWER SUPPLY SHALL
BE DE-ENERGIZED WHENEVER
ANY COMPONENTS ARE REPLACED.

4.2 PREVENTATIVE MAINTENANCE:

The principle item that will require attention is the cooling arrangement. The power supply generally requires some amount of convection air currents for cooling purposes. These supplies make use of internal forced air cooling. It is important to keep the rear of the unit clear of obstructions which might reduce the effectiveness of the fan.

CAUTION ! !

VACUUM CLEANER MAY LOOSEN THE SMALL PLUG-IN TRANSISTORS.

4.3 MEASUREMENTS AND TESTS

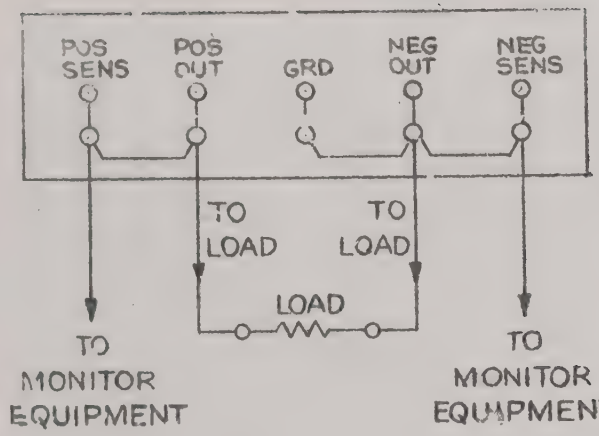
4.3.1 Sensing Connection: Sensing lead connections are of utmost importance in making proper regulation measurements. It is recommended that the sensing connections be made directly at the output terminal points rather than at a remote load point. Although the regulation measurement should check correctly at a remote point as well as at the supply terminals, it is well to ascertain that the power supply itself is operating properly without introducing the possibility of extraneous external wiring problems. Thus, all measurements should be made with "local" sensing connections, i.e., with the Sensing terminals jumpered directly to the corresponding Output terminals. One other point of caution in proper measurement technique is the following:

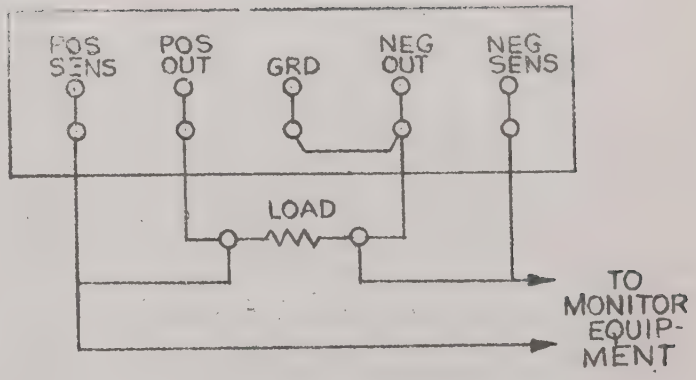
> It is absolutely essential that the measuring equipment connections be made directly to the sensing terminals, whereas the load lead connections must be made directly to the Output terminals. Figure 4-1 shows proper and improper connections for measurements taken with "local" and "remote sensing" connections.

Various measurements can be made using essentially the same connections, but using different instrumentation. The following paragraphs describe the basic parameters which may be tested.

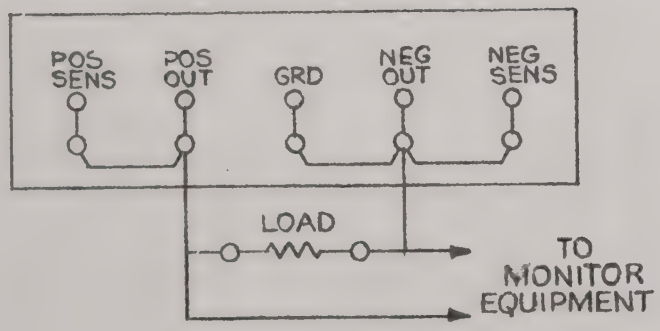
4.3.2 Regulation Checks: Since regulation of modern power supplies can be as low as 0.001%, special measuring techniques must be employed to accurately check the various regulation parameters. It is necessary to use an external source of DC voltage of approximately the same value as the power supply output as a "bucking" source, connected as shown in Figure 4-2. This DC bucking voltage can be either an electronic, null balance differential voltmeter, or a group of batteries connected in series (or another power supply), furnishing a DC potential slightly larger than the output voltage of the power supply under test. When using an differential voltmeter, the voltmeter is built right into the test equipment. When a "bucking" battery is used the voltmeter should have a full-scale range low enough to detect the magnitude of regulation expected.

A multi-tester used on the 1 volt range will usually be adequate, since approximately 10 millivolts can be observed reasonably well. The point to note here is that the voltmeter is used to measure only the difference between two almost equal voltages. The balance adjustment (either in the electronic unit, or the test set-up of the diagram) is used to bring the meter needle to approximately midscale before testing, so that the deviation above or below the normal output of the supply under test can be observed.

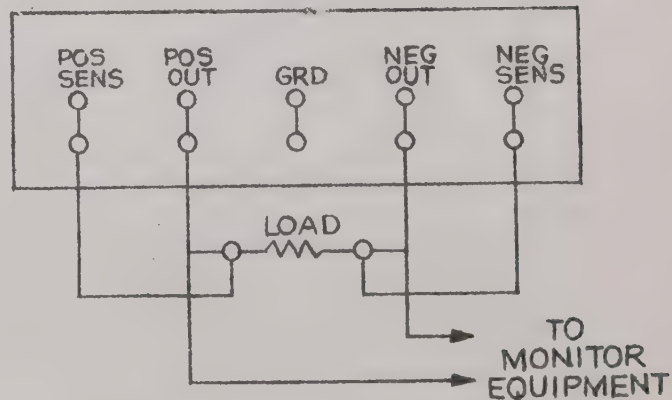




INCORRECT



INCORRECT



LOCAL SENSING

REMOTE SENSING

MEASUREMENT CONNECTIONS WITH LOCAL SENSING AND REMOTE SENSING

FIG. 4-1

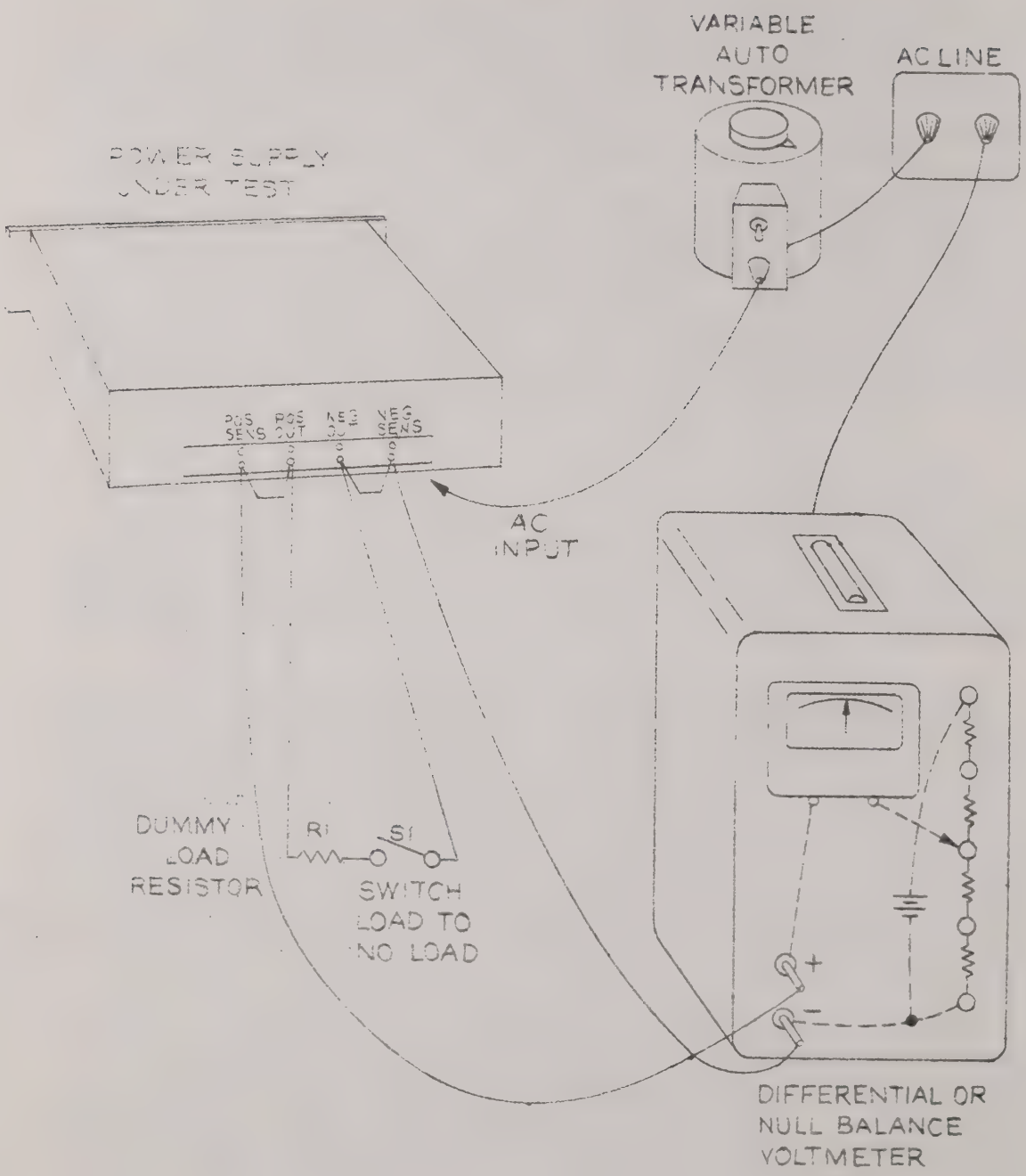
4.3.3 Static Load Regulation: The dummy load (R1) of Figure 4-2 is selected to draw full load current at the nominal output voltage of the supply. The difference between the differential voltmeter readings with the switch open and closed (allowing the needle to come to rest before reading), gives the static load regulation in volts. When load changes are made, it may be necessary to readjust the line voltage to its nominal value.

4.3.4 Static Line Regulation: With the load set at some fixed value, either no load, full load, or some in-between point, the input line is varied by means of the variable auto-transformer shown in Figure 4-2. Note that if this measurement is made under a heavy load condition, the auto-transformer must be selected to supply the necessary input volt-amperes. The difference between the differential voltmeter reading for different line voltage conditions (allowing the needle to come to rest before reading), gives the static line regulation in volts.

4.3.5 Ripple: Either a sensitive VTVM or oscilloscope may be connected directly across the power supply sensing terminals for this measurement. The same set-up as used for the regulation checks may be used if it is desired to observe the ripple under different conditions of the voltage and load current. Be sure to make the measurement connections at the sensing terminals rather than at the load terminals.

4.3.6 Dynamic Regulation and Recovery Time: In the test-set-up described above for Static Load or Line Regulation, a calibrated oscilloscope should be substituted for the differential voltmeter. Maximum deflection and recovery time are measured directly as a dummy load of appropriate value is switched in and out of the circuit. A mercury switch is recommended to minimize arcing, or else an electronic switch should be used. If available, the latter is highly desirable, since the response is readily displayed on the oscilloscope. If recovery time is the parameter under investigation, the switch must be such that the rise and fall time of the current step be at least five times faster than the anticipated recovery time.

4.3.7 Stability: A detailed check for improper drift and intermittent failure can be made by utilizing the same test arrangement as for static regulation measurements. The only requirement is that the differential voltmeter used must have stability of an order of magnitude better than that of the power supply. If available, a stable recorder may be substituted for the differential voltmeter in the drawing, thereby procuring a continuous tracing of the power supply stability.



REGULATION CHECK
TYPICAL LAYOUT

FIG. 4-2

4.4 TROUBLESHOOTING:

The various ways in which DC power supply can deviate from normal operation are listed below. Each condition is treated separately in the charts that follow. Component symbol designations refer to the schematic diagram at the rear of the manual. Parts locations are indicated in the parts layout photograph also included at the rear.

MALFUNCTION	TYPICAL MAGNITUDE
1. No output voltage at any control setting.	Zero or negative DC output voltage.
2. Low output voltage.	Maximum output voltage obtainable at no load is less than maximum rating.
3. High output voltage.	Minimum output voltage obtainable at no load is more than maximum rating.
4. Failure to regulate.	Output voltage drops 5% or more when load is applied, or varies ±2% or more under a ±10% variation in line voltage.
5. Poor regulation.	Regulation better than above, but not within specification.
6. Excessive ripple.	
A. With good regulation.	RMS ripple exceeds specification, but regulation is within specification.
B. With poor regulation.	RMS ripple exceeds specification, and regulation exceeds specification.
7. Instability.	
A. Random large excursions.	Output voltage "hops" intermittently by 5% or more with constant load, and constant line voltage.
B. Gradual drift in one direction.	Output voltage changes by 1% or more per minute, after 15-minute warmup.
C. Excessive drift under heavy load only.	Output voltage changes by 1% or more per minute after a 15-minute warmup, but only after application of a heavy load.

4.4 TROUBLESHOOTING (cont'd)

MALFUNCTION	TYPICAL MAGNITUDE
8. Inadequate transient suppression.	Failure to "zero-lag". Upon sudden application of a full load increase, output voltage dips sufficiently to cause a visible momentary deflection of the voltmeter needle.
9. Oscillation.	
A. High frequency	Under constant load, output voltage is modulated by sawtooth or sine-wave with frequency of 200 cycles or more per second.
B. Low frequency.	At constant load, output voltage exhibits relaxation modulation at or below 200 cycles per second.

NO OUTPUT

SYMPTOM	POSSIBLE CAUSE	REMEDY
Pilot light (DS1) not lit.	No line power, or defective input connection.	Check power source lines and connections.
	Input fuse (F1) blown.	Replace fuse. If fuse blows repeatedly, do not overfuse.
Repeated blowing of fuse (F1).	Shorted rectifiers (CR1, CR2, CR3, CR4, CR5 or CR6).	Replace
	Shorted capacitors (C3, C4 or C5).	Replace.
Pilot light (DS1) lit.	Output fuse (F2) blown.	Replace fuse but do not overfuse.
Output fuse (F2) blows repeatedly, pilot light (DS1) lit.	Dead short on output circuit.	Clear short or short in external wiring and/or circuitry.
	External.	Check for overload.
	Internal.	Shorted filter capacitor (C9) or wiring short.

4.4 TROUBLESHOOTING (cont'd)

NO OUTPUT

SYMPTOM	POSSIBLE CAUSE	REMEDY
Unregulated DC across (C3) zero or low. Fuses (F1 and F2) not blown.	Open rectifiers (CR1 and/ or CR2).	Replace rectifier or rectifiers.
	Primary secondary power transformer windings open.	Replace transformer (T1).
Unregulated DC present at (C3), but more than 15-25% higher than DC output.	Entire, or major part of unregulated DC voltage across (C3) absorbed by regulator transistors (A2Q1) and (A3Q1). Caused by short or excessive leakage between base of driver (A1Q1) or regulator transistors (A2Q1) and (A3Q1), and any positive voltage or ground. (For example: If positive output is operated at chassis ground and a wiring short or excessive leakage exists between base of (A1Q1) and chassis).	Inspect for short. Isolate driver transistor from heat sink and chassis, and operate unit for brief interval. if this restores normal operation, replace driver insulation, and/ or driver itself, as necessary. If not cleared, repeat for regulators (A2Q1) and (A3Q1).
	Amplifier or sensing circuit defective.	Check by momentarily shorting base to collector of (A1Q1). If DC output is restored, amplifier or sensing circuit at fault. See end of this section for amplifier check.
	Rate sensing capacitor (C10) shorted internally, or by external wiring short.	Inspect for short. Disconnect one terminal of capacitor. If DC output is restored, replace capacitor.

4.4 TROUBLESHOOTING (cont'd)

NO OUTPUT

SYMPTOM	POSSIBLE CAUSE	REMEDY
	Defective driver transistor (A1Q1).	Check by momentarily shorting base to collector on driver transistor at no load. Replace driver transistor.
	Ammeter (M1) open.	Check by momentarily shorting meter terminals. Replace.
	(R3 through R5) all open.	Replace.
	(R8) open.	Replace.

LOW VOLTAGE OUT

SYMPTOM	POSSIBLE CAUSE	REMEDY
Unregulated DC present at (C3) in expected magnitude (15 to 30% higher than output voltage at nominal line voltage at no load).	Amplifier or sensing circuit defective.	Check by momentarily shorting base to collector of (A1Q1). If this restores DC output, check sensing voltage divider. See end of this section for amplifier check.
	Rate sensing capacitor (C10) has excessive leakage.	Disconnect one terminal of capacitor. If this restores DC output, replace capacitor.
	Defective diode in rectifier (CR1 or CR2).	Check for low back resistance in any diode and replace as necessary.
	Filter capacitor (C1) opens.	Replace capacitor.

4.4 TROUBLESHOOTING (cont'd)

HIGH VOLTAGE OUT

SYMPTOM	POSSIBLE CAUSE	REMEDY
Output voltage adjust knob has little or no control over DC output.	External sensing circuit improperly connected. Internal sensing voltage divider or wiring open.	With power off, check continuity of sensing leads, internal sensing circuit from positive output terminals to amplifier input (27) and from negative output terminal to neutral bus of amplifier (24).
Output control effective. Driver base (A1Q1) negative with respect to negative output terminal.	Bleeder resistor (R2) open, or regulator transistors (A2Q1 and A3Q1). I_{co} drain open (R6).	Check by applying full load. If this restores normal operation, check for open resistor or connection.
	Defective amplifier	See amplifier check at end of this section.
	Defective amplifier power supply.	Check voltage across filter capacitor (C5), (C6) as shown on schematic diagram. If correct check resistors (R7 and R9) for opens. If o.k., check the capacitors, (C4 and C5) diodes (CR3 thru CR6) and bias windings of transformer (T1). Terminals (6-8).
Driver base (A1Q1) positive with respect to negative output terminal.	Defective driver and/ or pass transistor.	Check for shorted transistors.

4.4 TROUBLESHOOTING (cont'd)

NO REGULATION

SYMPTOM	POSSIBLE CAUSE	REMEDY
Load regulation is 5% or more, line regulation 2% or more.	Defective amplifier.	See amplifier check at end of this section.
	Defective amplifier power supply.	Check voltages values of filter capacitors (C4), (C5). If incorrect, check the capacitors, diodes (CR3 thru CR6) and auxiliary secondary winding of transformer (T1). Check (R7 and R9) for open.
	Open (R13).	Replace.
	Very low performance transistor in regulator or driver circuit.	Check for equal voltages across resistors in series with emitters of power transistors, to detect defective transistor. Check transistors in a transistor test set or by substitution.
	Shorted (CR12).	Replace

POOR REGULATION

SYMPTOM	POSSIBLE CAUSE	REMEDY
Load regulation less than 5%, but not within specifications.	External sensing circuit incorrectly connected.	Check by operating unit with sensing terminals temporarily jumpered to the local output terminals. (Observe correct polarity).
	Low gain amplifier.	See amplifier check at rear of the section.
	Low beta in driver or power transistor.	Check by substitution or in transistor tester. Beta of 20 or more is acceptable.

4.4 TROUBLESHOOTING (cont'd)

POOR REGULATION

SYMPTOM	POSSIBLE CAUSE	REMEDY
	Excessive resistance in output fuse (F2), fuseholder, or output connection.	Check output connections for loose or corroded terminals. Check fuse and holder by operating the unit with a temporary jumper shorting the fuseholder.
	Oscillating amplifier.	Check (C7 and C8) for proper value. See amplifier check at the rear of this section.

EXCESSIVE RIPPLE

SYMPTOM	POSSIBLE CAUSE	REMEDY
Output regulation is within specifications.	Circuit not bypassed to ground.	One output terminal of the supply should be connected to chassis ground whenever practical, either directly or through a 0.1 mfd. capacitor of appropriate voltage rating.
	Filter capacitor (C3, C4 or C5) open or of low value.	Replace.
	Note: Ripple at (C3) should not exceed 5%.	Replace.
	Rate-sensing capacitor (C10) open or of low value.	Replace.
	Hum pickup in enternal sensing leads.	Check by operating unit with sensing terminals temporarily jumpered to local output terminals. Shield external sensing leads.

4.4 TROUBLESHOOTING (cont'd)

EXCESSIVE RIPPLE

SYMPTOM	POSSIBLE CAUSE	REMEDY
	Low gain amplifier.	See amplifier check at end of this section.
	Open (CR14).	Replace.
Output regulation poor.	Low beta in power transistor or driver transistor.	Check by substitution or in transistor test set. Beta of 20 or more is acceptable.
	Low gain amplifier.	See amplifier check at the end of this section.
	Defective amplifier power supply.	Check diodes (CR3 thru CR6) for shorts, or open capacitors (C4), (C5) for open, low value, or high leakage. Check diodes (CR8), (CR10) and resistors (R7) and (R9).

INSTABILITY

SYMPTOM	POSSIBLE CAUSE	REMEDY
Random large excursions of output voltage	Intermittent failure of component or intermittent short or open in circuit.	Check primary power circuit by temporarily connecting base of driver transistor (A1Q1) to negative output terminal. If instability persists, check for intermittent breakdown in rectifiers (CR1 and CR2) or filter capacitors (C3 and C9). Check for intermittent opens or shorts in unregulated DC circuit. Check driver and power transistors in tester, or by substitution. Check for intermittent opens

4.4 TROUBLESHOOTING (cont'd)

INSTABILITY

SYMPTOM	POSSIBLE CAUSE	REMEDY
		or shorts, or defective component from (C3) to output terminals. Look for intermittent open or short, or intermittently defective component in (1) amplifier, (2) amplifier power supply, or (3) sensing voltage divider and external sensing circuit. Check amplifier connector for poor contact. Check rate-sensing capacitor (C10). Check voltage across (CR9, CR10 and CR13) for stability.
Gradual drift in one direction at any load, after 15-minute warmup.	Defective amplifier	See amplifier check at end of this section.
	Drifting zeners.	Check (CR8, CR10 and CR13). Replace if faulty.
	Output adjust potentiometer (R16) unstable.	Replace.

INADEQUATE TRANSIENT RESPONSE

NOTE: This condition should be checked by oscilloscope at the output terminals of the supply, with the sensing terminals temporarily jumpered to the corresponding output terminals. None of the load current should be permitted to flow through any portion of the oscilloscope leads or the sensing leads.

4.4 TROUBLESHOOTING (cont'd)

INADEQUATE TRANSIENT RESPONSE

SYMPTOM	POSSIBLE CAUSE	REMEDY
Regulation and ripple are within specification, and external sensing circuit is properly and firmly connected.	Bypass capacitor (C9) open, or very low in value.	Replace.
	Filter capacitor (C3) low in value.	Replace.

NOTE: A brief transient during switching is normal. The measurement of transient response may be complicated by indutive transients of 1 to 50 microsecond duration due to lead inductance etc., but since these are easily handled by means of local bypassing, they have no significance in determination of the transient response of the supply.

OSCILLATION

SYMPTOM	POSSIBLE CAUSE	REMEDY
Under constant load, output voltage varies at a cyclic rate (sawtooth or sine-wave) of 200 cycles or more per second.	Defective diodes (CR8), (CR10) or resistors (R7) or (R9).	Replace.
	Bypass capacitor (C9) is open or of low value.	Replace.
	Rate sensing capacitor (C10) or its circuit is open.	Replace.
	Suppressor capacitors (C8 or C7) in amplifier are open or of low value.	Replace.
Under constant load, output voltage varies in "sawtooth" manner at a frequency of 200 cycles or less.	Output capacitor (C9) is open.	Replace.
	Rate sensing capacitor (C10) is open, or of low value.	Replace.
	Excessive capacitance in external load circuit.	If load contains capacitance equal to or greater than output capacitor (C9), special precautions are necessary. Check with NJE Corp. engineering department.

4.4 TROUBLESHOOTING (cont'd)

OSCILLATION

SYMPTOM	POSSIBLE CAUSE	REMEDY
	Excessive amplifier gain.	If the beta (current gain) of one or more amplifier transistors is 150% or more of the manufacturer's bogie value, the increased gain which results (particularly at high ambient temperature) should result in this type of oscillation. Replacement of the transistor is required.

4.5 ALIGNMENT AND ADJUSTMENT:

The power supply has two controls that are factory adjusted and normally do not require attention in the field. If any of the components in the error-difference amplifier are replaced, the following readjustments may be necessary.

4.5.1 OUTPUT ADJUST calibration.

Step 1: Set OUTPUT ADJUST variable resistor (R16) completely clockwise. The unit may be operated at nominal line and at no load.

Step 2: Place calibrated voltmeter across output.

Step 3: Adjust variable resistor (R24) until full rated output voltage is reached.

4.5.2 Current Limiting Control, (R11).

Step 1: Set OUTPUT ADJUST variable resistor (R16) completely clockwise. Verify that the output is the full rated voltage.

Step 2: Place a calibrated ammeter in series with the load.

4.5.2 (cont'd)

NOTE: Ammeter (if provided) on unit may not have sufficient range.

Step 3: Apply a short circuit to power supply through external current monitor.

Step 4: Slowly rotate variable resistor (R11)until current level reaches the 110% limit.

4.6 FEEDBACK AMPLIFIER CHECK:

There are several methods which can be used in checking the performance and condition of the feedback amplifier.

Except for individually removing the transistors for a check by means of a transistor test set, and making continuity and resistance tests on the circuit and components, all methods require the amplifier to be energized with the proper potentials under the conditions found in the power supply for normal operation. For this reason, it is simplest to test the amplifier in position in the supply, first making certain that its DC power supply (transformer, rectifiers diodes (CR3 - CR6), capacitors (C4, C5), diodes (CR8, CR10) and resistors (R7, R9) is functioning properly. This can be quickly ascertained by checking the circuit voltages as indicated on the schematic diagram. Once this is done, the procedures given below can be used to check out the amplifier itself.

4.6.1 Voltage Check:

The simplest and most rapid direct check of the amplifier is made by connecting a temporary jumper from the base of transistor (Q5) to the base of transistor (Q6), thereby balancing the amplifier input stage, and checking for balanced voltages on the two amplifier stages. Any obvious discrepancy will indicate a defective stage, and simple analysis will pinpoint the defective connection or component. Verification is then made by testing the component itself or repairing the connection.

4.6.2 Signal Tracing Check:

Since there is an inherent amount of ripple at the input to the amplifier, this ripple signal can be used as a test signal for observing the amplifier performance with the aid of a test oscilloscope. (Ignore any spikes in the waveform). Use only the basic ripple signal when making amplitude calculations. In the event that the ripple is too small for practical use, a small 60-cycle sine-wave voltage of convenient amplitude (less than 1/4 volt) can be injected into the amplifier, applying it across amplifier terminals 28 and 24 for convenience. Measurement of the ripple at the input to the amplifier, and at the output of each successive amplifier stage will provide an effective check for amplifier performance. The ripple amplitude measured across the bases (or input) of the second stage transistors (Q3) and (Q4) should be 20 to 40 times the amplitude at the input to the first stage. The ripple at the base of the next stage, should be 15 to 30 times the ripple at the input to the previous stage. Radical departure from this set of conditions will point up a defective component or connection, which can then be isolated by inspection and individual test.

4.7 STABILITY CHECK:

A detailed check for improper drift and intermittent failure can be made by utilizing a test rig similar to that shown for precise regulation check in Figure 4-2. The voltage across the zener diode reference source (CR13) is "bucked out" and monitored by a 0 to 10 millivolt high impedance DC voltmeter, (null balance voltmeter). Drift or random instability will be readily visible in this test. Output voltages of the successive amplifier stages and regulating diodes (CR8) and (CR10) can then be monitored in the same manner. When checking a given amplifier stage by this method, the output of the previous stage should be shorted, to prevent external voltage variations from reaching the stage under test. When installing a new transistor in place of one shown to be defective, the stability check should be repeated, to make certain that the trouble has been eliminated.

NOTES:

1. ALL VOLTAGES ARE MEASURED WITH RESPECT TO NEG OUT TERMINAL, WITH UNIT OPERATING AT MAX. OUTPUT VOLTAGE AND CURRENT. INPUT LINE VOLTAGE - 115VAC.

2. CAUTION DO NOT OPERATE THIS SUPPLY WITH REMOTE CONTROL OR SENSING JUMPERS DISCONNECTED. REFER TO INSTRUCTION MANUAL FOR APPLICATION.

3. BOTTOM VIEW OF TRANSISTORS Q1Q5 AND Q1Q6 ONLY:

4. TOP VIEW OF ALL TRANSISTOR SOCKETS:

ON BOTH MODELS, M1 AND M2 ARE NOT SUPPLIED

SCHEMATIC FOR DC P
MODEL TR

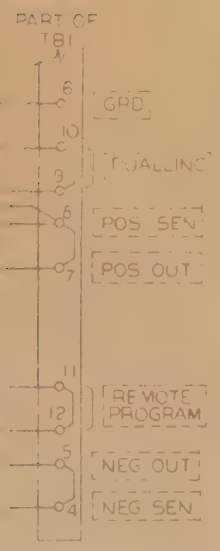
2A

POS

OUTPUT
0-36 VDC
0-2A

NEG

GRD

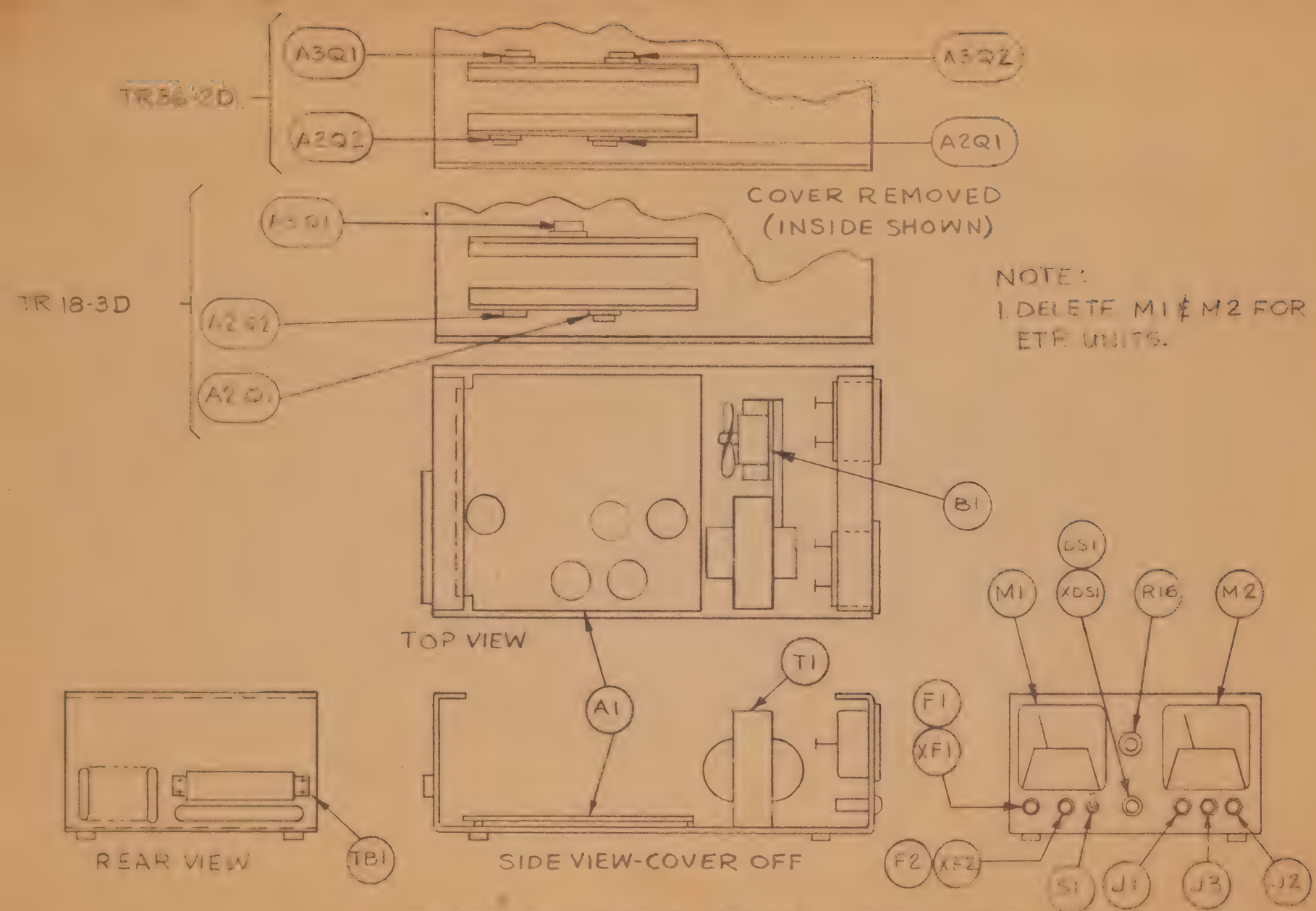


350 350UF

5000
2W

REV	DESCRIPTION	DATE
A	CR15 WAS CER330	7/8/94

POWER SUPPLY
836-2D



PARTS PLACEMENT-MAJOR COMPONENTS
TR & ETR LINE
FIG 5-2

103610

ABBREVIATIONS USED IN SPARE PARTS LIST

In Description Column: "SA" is used to mean "Same As" and "PO" is used to mean "Part Of". Where these symbols are used, the UNIT QTY, SPARE QTY, UNIT PRICE and NJE PART NO. columns are all blank.

In Value Column: The use of the letter R to indicate a decimal point is illustrated by the following examples: 5.6KΩ is written as 5R60K. 1/2 Watts is written as R500 W. The use of zeroes does not imply a precision to the indicated number of decimal places but is a requirement of the proper handling of the Data Processing Cards from which these spare parts lists are written.

The standard symbols for electrical units are used and usually appear in the columns immediately to the left of the dashed and solid lines in the Value field. In all cases, the symbol Ω is not printed for resistors and is understood. For example: 200Ω is written 200 and 2.7MΩ is written 2R70 M.

In Reference Designation Column: The reference designations are those which interrelate the Spare Parts List, the Schematic Diagrams and the Parts Placement drawings. The symbols are those of MIL - STD 16. Where the reference designation is an "A" (meaning a subassembly) a Spare Parts List bearing the NJE Part Number of that assembly is included in the Spare Parts List section.

Deviations: Where minor deviations are accomplished by modifying a standard unit, a Spare Parts List which only shows the deletions and additions from the enclosed standard Spare Parts List is used.

Form SP 5 - 5M - 6/64

N J E Corp. KENILWORTH, N. J.

Spare Parts List

REFERENCE DESIGNATION	DESCRIPTION	VALUE	UNIT QTY.	SPARE QTY.	UNIT $ PRICE	UNIT ¢	NJE PART NO.
	TR36 20						81488
A1	107PC 2		1	1			81491
A2	HS ASSY		1	1			81138
A3	HS ASSY		1	1			81829
B1	BLOWER CO CPS	115V 1PH 3IN	1	1	13	50	227
BS1	PO XDS1						
F1	FUSE CARTRIDGE	3R00 A 250 V	2	10		20	173
F2	FUSE CARTRIDGE	2R00 A 250 V	1	5		20	25
J1	CONNECTOR RECEPT	1 PIN 15 A	1	1	1	00	20667
J2	CONNECTOR RECEPT	1 PIN 15 A	2	1	1	00	20668
J3	SA J2						
M1	AMMETER DC	3R0 A	1	1	22	00	36
M2	VOLTMETER DC	30R0 V	1	1	22	00	41
R10	RES VAR WW	5R00 K 2 W	1	1	2	25	152
S1	SWITCH	3P3T 15 A	1	1	1	50	20605
T1	TRANSFORMER		1	1	26	10	81095
TB1	TERMINAL BOARD	12 TERM 15 A	1		1	68	124
XD31	LAMPHOLDER	CL RED 115 V	1	1	1	00	20974
XF1	FUSE HOLDER	30 A 250 V	2			50	20831

1 - When ordering spare parts it is necessary to specify the serial number and model number (available on the warranty label on the rear of the unit) and the NJE Part No. from this spare parts list.
2 - Unit Price shown above is subject to change without prior notice.
3 - NJE Corp. reserves the right to make design improvements on this unit without prior notice.
4 - Spare Quantity shown above is for one year isolated service.

Form SP 5 - 5M - 6/64

N J E Corp. KENILWORTH, N. J.

Spare Parts List

REFERENCE DESIGNATION	DESCRIPTION	VALUE	UNIT QTY.	SPARE QTY.	UNIT $ PRICE	UNIT ¢	NJE PART NO.
XF2	SA XF1						
	107PC 2						81491
C1	CAP FXD CERAMIC	R1UF 500 V	2	1	1	25	167
C2	SA C1						
C3 1	CAP FXD ELECT	1500UF 65 V	2	1	3	95	20660
C3 2	SA C3 1						
C4	CAP FXD ELECT	300UF 150 V	2	1	3	00	14
C5	SA C4						
C6	CAP FXD CERAMIC	R1UF 75 V	1	1	1	00	3
C7	CAP FXD CERAMIC	3000PF 150 V	2	1		50	4
C9	CAP FXD ELECT	3X350UF 50 V	1	1	4	10	20771
C10	CAP FXD TANTALUM	2R2UF 50 V	1	1	4	00	20099
C11	SA C7		1	1			
C12	CAP FXD CERAMIC	5000PF 1KV	1	1		30	21787
CR1	DIODE RECTIFIER SI	2 A 200 V	2	2	3	00	103232
CR2	SA CR1						
CR3	DIODE RECTIFIER SI	750MA 300 V	9	3	1	20	136
CR4	SA CR3						

1 - When ordering spare parts it is necessary to specify the serial number and model number (available on the warranty label on the rear of the unit) and the NJE Part No. from this spare parts list.
2 - Unit Price shown above is subject to change without prior notice.
3 - NJE Corp. reserves the right to make design improvements on this unit without prior notice.
4 - Spare Quantity shown above is for one year isolated service.

Form SP 5 - 5M - 6/64

N J E Corp. KENILWORTH, N. J.

Spare Parts List

REFERENCE DESIGNATION	DESCRIPTION	VALUE	UNIT QTY.	SPARE QTY.	UNIT $ PRICE	UNIT ¢	NJE PART NO.
CR5	SA CR3						
CR6	SA CR3						
CR7	SA CR3						
CR8	DIODE BKDOWN 10PC	150MW 5R6 V	2	1	5	00	135
CR9	SA CR3						
CR10	DIODE BKDOWN 10PCT	10 W 18 V	1	1	9	50	102014
CR11	SA CR3						
CR12	SA CR3						
CR13	SA CR8						
CR14	SA CR 3						
Q1	TRANSISTOR PNP SI	10 W 70 V	1	1	4	00	473
Q2	TRANSISTOR PNP SI	200MW 25 V	3	1	2	40	139
Q3	SA Q2						
Q4	SA Q2						
Q5	TRANSISTOR NPN SI	200MW 18 V	2	1	5	00	21711
Q6	SA Q5						
R1	RES FXD WW	600R00 10 W	2	1	1	75	104
R2 1	RES FXD WW	1R50 K 10 W	2	1	1	75	106
R2 2	SA R2 1						

1 - When ordering spare parts it is necessary to specify the serial number and model number (available on the warranty label on the rear of the unit) and the NJE Part No. from this spare parts list.
2 - Unit Price shown above is subject to change without prior notice.
3 - NJE Corp. reserves the right to make design improvements on this unit without prior notice.
4 - Spare Quantity shown above is for one year isolated service.

Form SP 5 - 5M - 6/64

N J E Corp. KENILWORTH, N. J.

Spare Parts List

REFERENCE DESIGNATION	DESCRIPTION	VALUE	UNIT QTY.	SPARE QTY.	UNIT PRICE $	UNIT PRICE ¢	NJE PART NO.
R3	RES FXD WW	R50 5 W	3	1	1	20	100
R4	SA R3						
R5	SA R3						
R6	RES FXD WW	2R00 K 10 W	1	1	1	50	1751
R7	RES FXD WW	1R00 K 10 W	1	1	1	75	105
R8	RES FXD WW	1R00 10 W	1	1	1	75	1727
R9	RES FXD WW	3R90 K 3 W	1	1		86	96
R10	RES FXD COMP	150R00 R500 W	1	1		10	55
R11	RES VAR WW	200R00 2 W	1	1	1	75	20917
R12	RES FXD COMP SPCT	1R00K R500 W	1	1		20	451
R13	RES FXD COMP	1R50 K R500 W	1	1		10	61
R14	RES FXD COMP	470R00 R500 W	1	1		10	57
R15	RES FXD COMP SPCT	15R00 K R500 W	1	1		20	530
R17	RES FXD COMP	620R00 R500 W	1	1		10	59
R16	SA R1						
R19	RES FXD COMP SPCT	2R70K R500 W	2	1		20	185
R20	SA R19						
R21	RES FXD COMP SPCT	10R00 K R500 W	1	1		20	475
R22	RES FXD WW	330R00 3 W	1	1		86	95

1 - When ordering spare parts it is necessary to specify the serial number and model number (available on the warranty label on the rear of the unit) and the NJE Part No. from this spare parts list.
2 - Unit Price shown above is subject to change without prior notice.
3 - NJE Corp. reserves the right to make design improvements on this unit without prior notice.
4 - Spare Quantity shown above is for one year isolated service.

N J E Corp. KENILWORTH, N. J.

Spare Parts List

REFERENCE DESIGNATION	DESCRIPTION	VALUE	UNIT QTY.	SPARE QTY.	UNIT $ PRICE	UNIT ¢	NJE PART NO.
R23	RES FXD COMP 5PCT	270R00 R500 W	1	1		20	183
R24	RES VAR WW	500R00 R250 W	1	1	5	00	118
R25	RES FXD WW	560R00 3 W	1	1		86	94
R28	RES FXD WW	R50 5 W	1	1	1	20	100
R30	RES FXD COMP 5PCT	2R20K R500 W	1	1		20	1024
XQ2	SOCKET TRANSISTOR	4PIN	5			70	128
XQ3	SA XQ2						
XQ4	SA XQ2						
XQ5	SA XQ2						
XQ6	SA XQ2						
	H SK SPARE						81138
Q1	TRANSISTOR PNP SI	50 W 55 V	2	2	7	00	161
	HS ASSY						81829
Q1	TRANSISTOR PNP SI	50 W 55 V	2	2	7	00	101892
Q2	SA Q1						

1 - When ordering spare parts it is necessary to specify the serial number and model number (available on the warranty label on the rear of the unit) and the NJE Part No. from this spare parts list.
2 - Unit Price shown above is subject to change without prior notice.
3 - NJE Corp. reserves the right to make design improvements on this unit without prior notice.
4 - Spare Quantity shown above is for one year isolated service.

DESIGNATION REFERENCE	DESCRIPTION	VALUE	▲ QTY UNIT	QTY SPARE	$ PRICE UNIT	¢	PART NO NTE

1 - Where ordering spare parts it is necessary to specify the serial number and model number (available on the warranty label on the rear of the unit) and the NTE P/N.
No. from the spare parts list.
2 - Spare Quantity shown above is for one year isolated service.
3 - NTE Corp. reserves the right to make design improvements on this unit without prior notice.
4 - Unit Price shown above is subject to change without prior notice.

NTE CORP. KENILWORTH, N.J.

SPARE PARTS LIST

MANUFACTURER'S REPRESENTATIVES

*California, Los Angeles
Ault Associates
931 So. Prairie Avenue
Inglewood, California
OR 8-6144

California, San Francisco
Ault Associates
120 Santa Margarita
Menlo Park, California
DA 6-1760

Canada, Montreal
Radionics, Ltd.
8230 Mayrand Street
Montreal, Canada
REgent 9-5517

Canada, Ontario
Radionics, Ltd.
4938 Yonge Street
Willowdale, Ontario
222-3261

Colorado, Denver
Scientific Instrument Company
1435 So. Milwaukee Street
Denver 10, Colorado
AL 5-2777

Florida, Clearwater
W. Ben Wimberley Co., Inc.
532 South Fort Harrison Ave.
Clearwater, Florida
(813) 446-7072

Florida, Orlando
W. Ben Wimberley Co., Inc.
500 Osceola Street
Orlando, Florida
425-3083

*Illinois, Chicago
Ridgway Associates
3759 North Harlem Ave.
Chicago 34, Ill.
282-5929

Indiana, Indianapolis
1224 N. Capitol Avenue
Indianapolis 2, Indiana
MElrose 5-2401

Massachusetts, Boston
Burlingame Associates, Ltd.
7 Wellington Street
Waltham, Mass.
TWinbrook 4-1955

Michigan, Detroit
Ridgway Associates
3384 Twelve Mile Road
Berkley, Michigan
LIncoln 6-3312

Minnesota, Minneapolis
Ridgway Associates
7735 Morgan Avenue, So.
Minneapolis 23, Minnesota
866-3305

Missouri, Kansas City
Lee Mark Associates
4201 W. 86th Street
Shawnee-Mission, Kansas
Niagara 2-3313

Missouri, St. Louis
Lee Mark Associates
2001 Big Bend Blvd.
St. Louis 17, Mo.
MIssion 7-1470

New York, Mount Vernon
Burlingame Associates, Ltd.
510 South Fulton Avenue
Mt. Vernon, N. Y.
MOunt Vernon 4-7530

New York, Syracuse
Burlingame Associates, Ltd.
106 Pickard Building
E. Molloy Road, Syracuse, N. Y.
(315) 454-2408

No. Carolina, Burlington
M. J. McDonald Co.
514 Hillcrest Avenue
Burlington, N. Carolina
226-7177

No. Carolina, Winston-Salem
M. J. McDonald Co.
Whippoorwill Drive, Rt. 1
Pfafftown, N. C.
WAbash 4-2182

Ohio, Dayton
Ridgway Associates
3898 Linden Avenue
Dayton 29, Ohio
CLearwater 2-5604

Ohio, Cleveland
Ridgway Associates
5249 Broadview Road
Cleveland 34, Ohio
(216) 749-6626

Penna., Philadelphia
Burlingame Associates, Ltd.
222 Long Lane
Upper Darby, Pa.
JAckson 8-6080

Texas, Dallas
Carey-Wolf Co.
P.O. Box 12425
Ft. Worth, Texas
TA 3-5383(Dallas)

Texas, Ft. Worth
Carey-Wolf Co.
P.O. Box 12425
Ft. Worth, Texas
PE 8-1702

Texas, Houston
Carey-Wolf Co.
P.O. Box 60338
Houston, Texas
OL 4-2114

Washington, Seattle
Ray Johnson Co., Inc.
1011 N.E. 69th Street
Seattle 15, Washington
LA 4-5170

Washington, D. C.
Burlingame Assoc., Ltd.
8218 Wisconsin Ave., N.W.
Washington 14, D. C.
OLiver 4-6400

*Local Service Centers.

Our Warranty:

N J E Corp. warrants each power supply manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replacing any defective parts thereof, except tubes, semi-conductors and fuses. This warranty is effective for five years after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and which upon our examination is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started. Written permission must be obtained from the factory, before a supply may be returned for examination.

NJE CORPORATION
Electronic Development & Manufacturing
Kenilworth, New Jersey • Tel. (201 Area Code) 272-6000
TELEFAX: FFP • TWX: (201 Area Code) 276-7630